

PCT

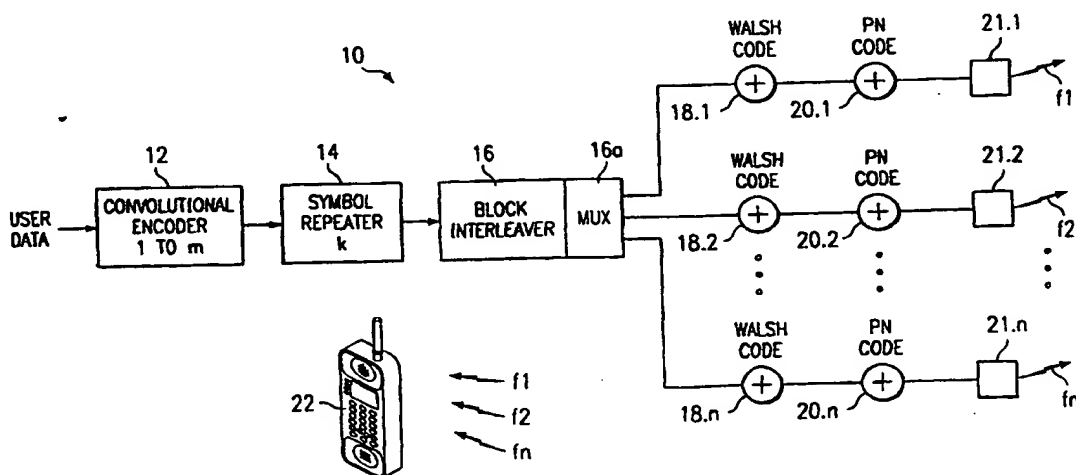
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L 27/26, 5/02, H04B 1/69, H03M 13/22		A1	(11) International Publication Number: WO 98/59473
			(43) International Publication Date: 30 December 1998 (30.12.98)
(21) International Application Number: PCT/CA98/00594		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: 17 June 1998 (17.06.98)			
(30) Priority Data: 60/050,986 21 June 1997 (21.06.97) US 08/954,686 20 October 1997 (20.10.97) US			
(71) Applicant: NORTHERN TELECOM LIMITED [CA/CA]; World Trade Center of Montreal, 8th floor, 380 St. Antoine Street West, Montreal, Quebec H2Y 3Y4 (CA).			
(72) Inventor: JALALI, Ahmad; 7424 Wildflower Drive, Plano, TX 75024 (US).			
(74) Agents: O'NEILL, T., Gary et al.; Gowling, Strathy & Henderson, Suite 2600, 160 Elgin Street, Ottawa, Ontario K1P 1C3 (CA).			
		Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	

(54) Title: CHANNEL CODING AND INTERLEAVING FOR TRANSMISSIONS ON A MULTICARRIER SYSTEM



(57) Abstract

A system and method that codes and interleaves data onto separate channels for transmission in a wireless multicarrier system, further comprising a code division multiple access (CDMA) transmitter for each of the carriers. The multicarrier wireless transmission system has an input terminal for receiving a plurality of user data bits. The system adds error-correcting bits to the user data bits. The system then arranges and stores the combination of error-correcting bits, collectively coded symbols, in a two dimensional matrix. The system arranges the coded symbols by writing them into the matrix according to columns, from left to right. The system then retrieves the symbols from the matrix according to rows, from top to bottom. The system then transmits the retrieved symbols on different carrier frequencies such that consecutive symbols are each transmitted on a different carrier frequency.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

CHANNEL CODING AND INTERLEAVING FOR TRANSMISSIONS ON A MULTICARRIER SYSTEM

Technical Field

The invention relates generally to transmitting and receiving data in a telecommunication system and, more particularly, to a system and method for coding and interleaving data onto separate channels for transmission in a multicarrier system.

Background of the Invention

Generally, a wireless telecommunication system serves a defined area by dividing the area into cells. Each cell is served by a single base station, or cell site, and each cell site is connected to a message switching center ("MSC") via appropriate hardware links. A mobile unit is connected to the MSC by establishing a link with a nearby cell site using one or more radio frequency ("RF") channels, or carriers.

For various reasons, higher data rates are desirable in the RF link between the mobile unit and the cell site. For example, in a code division multiple access ("CDMA") system, data rates are somewhat restricted due to current standards that require a system bandwidth of 1.25 Megahertz (MHz). However, future requirements are expanding to support a system bandwidth of $n \times 1.25$ MHz, where n is an integer, thereby supporting backwards compatibility to the traditional 1.25 MHz bandwidth.

Once a system bandwidth of $n \times 1.25$ MHz is chosen, there are two conventional methods by which the data may be transmitted over the chosen bandwidth. One method, referred to as direct spread, encodes the data using a convolutional code, interleaves the resulting coded bit stream, encodes the interleaved symbols using a Walsh code unique to the user, further encodes the encoded symbols using a pseudo-noise (PN) code, and then transmits the resulting symbols, known as chips, on the entire $n \times$

1.25 MHz bandwidth. Using this method, the actual symbol rate on the RF carrier is $n \times 1.25$ million chips per second. Another method, referred to as multicarrier, splits the encoded data into n streams, encodes each stream using a Walsh and a PN code, and then transmits the resulting chips of each stream on a separate 1.25 MHz carrier. A CDMA compatibility standard for cellular mobile telecommunications systems, including greater detail in the above described methods, is described in MOBILE STATION-BASE STATION COMPATIBILITY STANDARD FOR DUAL-MODE WIDEBAND SPREAD SPECTRUM CELLULAR SYSTEM, TIA/EIA/IS-95 (July 1993), which is hereby incorporated by reference.

The multicarrier method described above does not adequately handle error conditions that occur over the separate carriers. For example, if several bit errors occur in sequential order, even the existence of error correcting code in the bit stream does not prevent certain data bits from being lost. To alleviate this problem, the multicarrier method interleaves, or shuffles, the order of the data bits separately on each carrier before transmission and then de-interleaves the data bits at the receiving end. This solution, however, has several deficiencies. For one, shuffling circuits are often used for each carrier, thereby requiring extra circuitry. Also, the shuffling does not take into account that certain carrier frequencies may be more robust at any particular time, and therefore subject to less errors than the other carrier frequencies.

Therefore, what is needed is a system and method that codes and interleaves data onto separate carriers for transmission in a multicarrier system.

Furthermore, what is needed is a system and method that does not require individual interleaving circuitry for each carrier of the multicarrier system.

Furthermore, what is needed is a system and method that utilizes a different carrier for consecutive bits of the error correcting code, thereby providing a versatile system that is less prone to errors.

Summary of the Invention

5 The foregoing problems are solved and a technical advance is achieved by a system and method that codes and interleaves data onto separate channels for transmission in a telecommunication system. In one embodiment, the multicarrier telecommunication system has an input terminal for receiving a plurality of user data bits. The system may add
10 error-correcting bits to the user data bits. The system then arranges and stores the combination of error-correcting bits, collectively coded symbols, in a two dimensional matrix. The system arranges the symbols by writing them into the matrix according to columns, from left to right. The system then retrieves the symbols from the matrix according to rows, from top to
15 bottom and transmits the retrieved symbols on different carrier frequencies such that consecutive symbols are each transmitted on a different carrier frequency.

As a result, the system reduces the effect of errors resulting from any single carrier. Furthermore, the arranging of the symbols is performed at a
20 central location, thereby obviating a need for each carrier to have its own shuffling device.

Brief Description of the Drawing

Fig. 1 is a block diagram of a base station and mobile unit in a multicarrier CDMA system.

25 Fig. 2 is a flow chart for a routine used to store symbols received by the base station of Fig. 1 into a matrix.

Fig. 3 is a flow chart for a routine to retrieve the symbols stored in the matrix of Fig. 2 for transmission.

Description of the Preferred Embodiment

Referring to Fig. 1, the reference numeral 10 designates a simplified base station of a multicarrier CDMA system. The base station 10 includes a convolutional encoder 12 (with a rate $1/m$), a symbol repeater (k times) 14, and a block interleaver 16 having an inverse-multiplexer 16a. The base station 10 utilizes multiple (n) carriers on separate frequencies $f_1 - f_n$, each with a bandwidth of 1.25 MHz and each adding a conventional Walsh code 18.1 - 18. n and PN code 20.1 - 20. n before being processed (baseband filtering, upconversion, amplification) and transmitted by devices 21.1 - 21. n , respectively. For the sake of example, only the forward link from base station 10 to a mobile unit 22 will be discussed, where a frame of r user data bits is received by the base station and a symbol stream divided of $m \times k \times r$ size blocks is transmitted.

When each bit of the user data enters the convolutional encoder 12, it is encoded into m symbols. The encoded symbols are then provided to the symbol repeater 14 where each symbol is repeated k times. The convolutional encoder 12 and the symbol repeater 14 are conventional devices for providing error-correcting capability, and for the sake of brevity, will not be further discussed.

Referring to Fig. 2, a method 50 is used to interleave the symbol stream produced from the symbol repetition block 14. At step 52, the block interleaver 16 forms a matrix of $m \times k \times q$ rows by p columns, where q and p are positive integers and

$$p \times q = r. \quad (1)$$

At step 54, the block interleaver 16 writes the encoded symbols into the matrix starting at the top of the first column and continuing down to the bottom of the first column. Once the first column is written, the symbols are filled into the second column from top to bottom. Step 54 is continued until all columns of the matrix are filled.

Referring to Fig. 3, once the matrix has been filled, a routine 70 is used to retrieve the symbols from the matrix for transmission on the different carriers $f1 - fn$. At step 72, the inverse-multiplexer 16a retrieves the first symbol on the first row and at step 74, sends the first symbol to the device 21.1 to be transmitted on carrier $f1$. At step 76, the inverse-multiplexer then sends the following symbols on the first row sequentially to be transmitted on carriers $f2$ through fn , one on each carrier until a symbol is transmitted on each of the n carriers. This step is then repeated with the next n symbols on the first row until all symbols of the first row are transmitted. At step 78, a determination is made as to whether any more rows are available. If not, execution stops. Otherwise, execution returns to step 72 where the inverse-multiplexer 16a retrieves the first symbol of the second row and at step 74, sends this symbol to the device 21.2 to be transmitted on the carrier $f2$. The inverse-multiplexer then sends the following symbols on the second row to be transmitted on carriers $f3, f4, \dots, f1$ until n symbols are transmitted on each of the n carriers. This step is then repeated with the next n symbols on the second row until all symbols of the second row are transmitted. If more rows remain, the inverse-multiplexer 16a returns to step 72, retrieves the first symbol of the third row on carrier $f3$, and sends the remaining symbols to be transmitted on carriers $f4, f5, \dots, f4$, and so forth. On row $n+1$, the inverse-multiplexer 16a sends the first symbol to be transmitted on carrier $f1$, and the steps 72-78 are repeated. Likewise, the transmission of rows $n+2, n+n+2, n+n+n+2, etc.$, each start with carrier $f2$, and so forth for the remaining rows.

For the sake of example, a frame of 10 user data bits ($r = 10$) is encoded using a 1-to-3 ($m = 3$) rate convolutional code, repeated twice ($k = 2$) and then divided between three different carrier signals ($n = 3$). The resulting symbol stream is divided into blocks of 60 symbols, which are interleaved across time as well as the 3 carrier signals. A matrix, illustrated in Table 1, has twelve columns ($q = 2$) and five rows ($p = 5$).

Each symbol of the matrix is represented as either X_i , Y_i or Z_i which together represent the three bits that are generated from one information bit by the convolutional encoder 12, where i is between 1 and 10.

Furthermore, each of the symbols X_i , Y_i and Z_i are repeated twice by the symbol repeater 14. Using the method 50 described above, the symbols are written into the columns of the matrix as illustrated below.

Table 1 Interleaving Matrix

X_1	Z_1	Z_2	Y_3	Y_4	X_5	X_6	Z_6	Z_7	Y_8	Y_9	X_{10}
X_1	X_2	Z_2	Z_3	Y_4	Y_5	X_6	X_7	Z_7	Z_8	Y_9	Y_{10}
Y_1	X_2	X_3	Z_3	Z_4	Y_5	Y_6	X_7	X_8	Z_8	Z_9	Y_{10}
Y_1	Y_2	X_3	X_4	Z_4	Z_5	Y_6	Y_7	X_8	X_9	Z_9	Z_{10}
Z_1	Y_2	Y_3	X_4	X_5	Z_5	Z_6	Y_7	Y_8	X_9	X_{10}	Z_{10}

Once the symbols have been arranged in the matrix, the inverse-multiplexer 16a retrieves the symbols in an interleaved manner for transmission on the carriers $f1$, $f2$, and $f3$. Moving across each row of the matrix of Table 1 in sequential order, the inverse-multiplexer sends each symbol to be transmitted in the following sequence, as described in Table 2, below. In Table 2, the column "No." describes the sequence that each symbol is transmitted, the column "Symbol" corresponds to the name from Table 1, the column "(R,C)" identifies the row and column of Table 1 in which the symbol is stored, and the column "Freq." designates the carrier on which the symbol is transmitted.

Table 2 Transmission Sequence

No.	Symbol	(R,C)	Freq.
1	X_1	1,1	$f1$
2	Z_1	1,2	$f2$
3	Z_2	1,3	$f3$
4	Y_3	1,4	$f1$
5	Y_4	1,5	$f2$
6	X_5	1,6	$f3$
7	X_6	1,7	$f1$
8	Z_6	1,8	$f2$
9	Z_7	1,9	$f3$
10	Y_8	1,10	$f1$
11	Y_9	1,11	$f2$
12	X_{10}	1,12	$f3$
13	X_1	2,1	$f2$
14	X_2	2,2	$f3$

No.	Symbol	(R,C)	Freq.
15	Z_2	2,3	$f1$
16	Z_3	2,4	$f2$
17	Y_4	2,5	$f3$
18	Y_5	2,6	$f1$
19	X_6	2,7	$f2$
20	X_7	2,8	$f3$
21	Z_7	2,9	$f1$
22	Z_8	2,10	$f2$
23	Y_9	2,11	$f3$
24	Y_{10}	2,12	$f1$
25	Y_1	3,1	$f3$
...
59	X_{10}	5,11	$f2$
60	Z_{10}	5,12	$f3$

It is understood that the mobile unit 22 has a similar broadcasting feature as described above for the base station 10. Furthermore, both the mobile unit 22 and the base station 10 also include receiver units for receiving and storing each symbol in a scheme opposite to the scheme described above, thereby allowing the data stream to be de-interleaved and fully restored.

In another embodiment, the block interleaver 16 may retrieve the symbol at the j^{th} column and i^{th} row of the matrix on carrier frequency f_m such that:

$$m = (((j-1) \times r + i - 1) \text{ MOD } n) + 1, \quad (2)$$

where r is the number of rows in the matrix, n is the number of carrier frequencies such that $1 \leq m \leq n$, and the function MOD signifies a modulus operation. By using equation (2) above, the interleaver 16 is ensured that no two consecutive coded symbols in the original coded sequence are transmitted on the same carrier frequency.

Therefore, although illustrative embodiments of the invention have been shown and described, other modifications, changes, and substitutions are intended in the foregoing disclosure. For example, the convolutional encoder 12 could be left out so that the symbol repeater 14 provides the only source of error correction capability. Also, Table 1 can be arranged according to rows, thereby allowing Table 2 to retrieve the symbols according to columns. Furthermore, the present invention is not limited to cell-based telecommunication systems, but instead may be used in many different types of systems, including wired-transmission systems. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

WHAT IS CLAIMED IS:

- 1 1. A telecommunication system comprising:
2 an input terminal for receiving a plurality of user data bits;
3 an error-correction device for generating a sequence of coded symbols
4 from the user data bits;
5 an interleaver for arranging and storing the coded symbols in a
6 matrix;
7 an inverse-multiplexer for retrieving the coded symbols stored in the
8 matrix;
9 wherein the matrix is two-dimensional, the interleaver arranges the
10 coded symbols according to the first dimension and the inverse-multiplexer
11 retrieves the coded symbols according to the second dimension.
- 1 2 The system of claim 1 further comprising a device for repeating the
2 coded symbols.
- 1 3. The system of claim 1 wherein the error correction device is a
2 repeater and the sequence of coded symbols include duplicates of the user
3 data bits.
- 1 4. The system of claim 1 being a wireless multicarrier system further
2 comprising a code division multiple access ("CDMA") transmitter for each of
3 the carriers.
- 1 5. The system of claim 4 wherein a sub-sequence of multiple coded
2 symbols are generated for each user data bit and wherein consecutive
3 symbols of the sub-sequence are transmitted on different carriers.

1 6. The system of claim 2 utilizing multiple carriers wherein the repeated
2 coded symbols are sequentially transmitted on different carriers.

1 7. The system of claim 1 wherein the error-correction device provides
2 forward error correction.

1 8. The system of claim 1 utilizing multiple carriers wherein each carrier
2 operates at a common bandwidth.

1 9. The system of claim 1 utilizing only a single carrier.

1 10. The system of claim 1 including a plurality of carriers and wherein
2 the system may selectively use one or more of the carriers.

1 11. A method for arranging a frame of consecutive bits for transmission
2 in a multicarrier system, the method comprising the steps of:
3 arranging and storing each bit of the frame in a two-dimensional
4 matrix according to the first dimension of the matrix;
5 retrieving each bit stored in the matrix according to the second
6 dimension to form an interleaved sequence of bits;
7 transmitting the interleaved sequence of bits with multiple carriers
8 such that no two consecutive bits in the interleaved sequence of bits are
9 transmitted on the same carrier.

1 12. The method of claim 11 wherein the step of transmission utilized
2 multiple carriers and no two consecutive bits of the frame are transmitted
3 on the same carrier.

1 13. The method of claim 11 wherein the first dimension represents a
2 plurality arrangements of the matrix, and where a first carrier transmits

3 the first bit of the first arrangement and the second carrier transmits the
4 first bit of the second arrangement.

1 14. The method of claim 11 wherein the step of transmitting utilizes a
2 code division multiple access ("CDMA") transmitter for each carrier of the
3 multicarrier system.

1 15. The method of claim 11 wherein the frame of bits includes error-
2 correcting code.

1 16. The method of claim 15 wherein the frame of bits also includes user
2 data and the error-correcting code is a duplicate of the user data.

1 17. The method of claim 11 wherein each carrier of the multicarrier
2 system operates at a common bandwidth.

1 18. The method of claim 11 wherein the multicarrier system utilizes only
2 a single carrier.

1 19. A system for arranging a frame of consecutive bits for transmission in
2 a multicarrier wireless system, the system comprising:

3 means for arranging and storing each bit of the frame in a two-
4 dimensional matrix according to the first dimension of the matrix;

5 means for retrieving each bit stored in the matrix according to the
6 second dimension to form an interleaved sequence of bits;

7 a code division multiple access transmitter for transmitting the
1 interleaved sequence of bits wherein the step of transmission utilizes
1 multiple carriers operating at a common bandwidth and wherein no two
2 consecutive bits of the frame are transmitted on the same carrier.

1 wherein the first dimension represents a plurality arrangements of
2 the matrix, and where a first carrier transmits the first bit of the first
3 arrangement and the second carrier transmits the first bit of the second
4 arrangement.

1 20. The system of claim 19 wherein the frame of bits includes error-
2 correcting code.

1/2

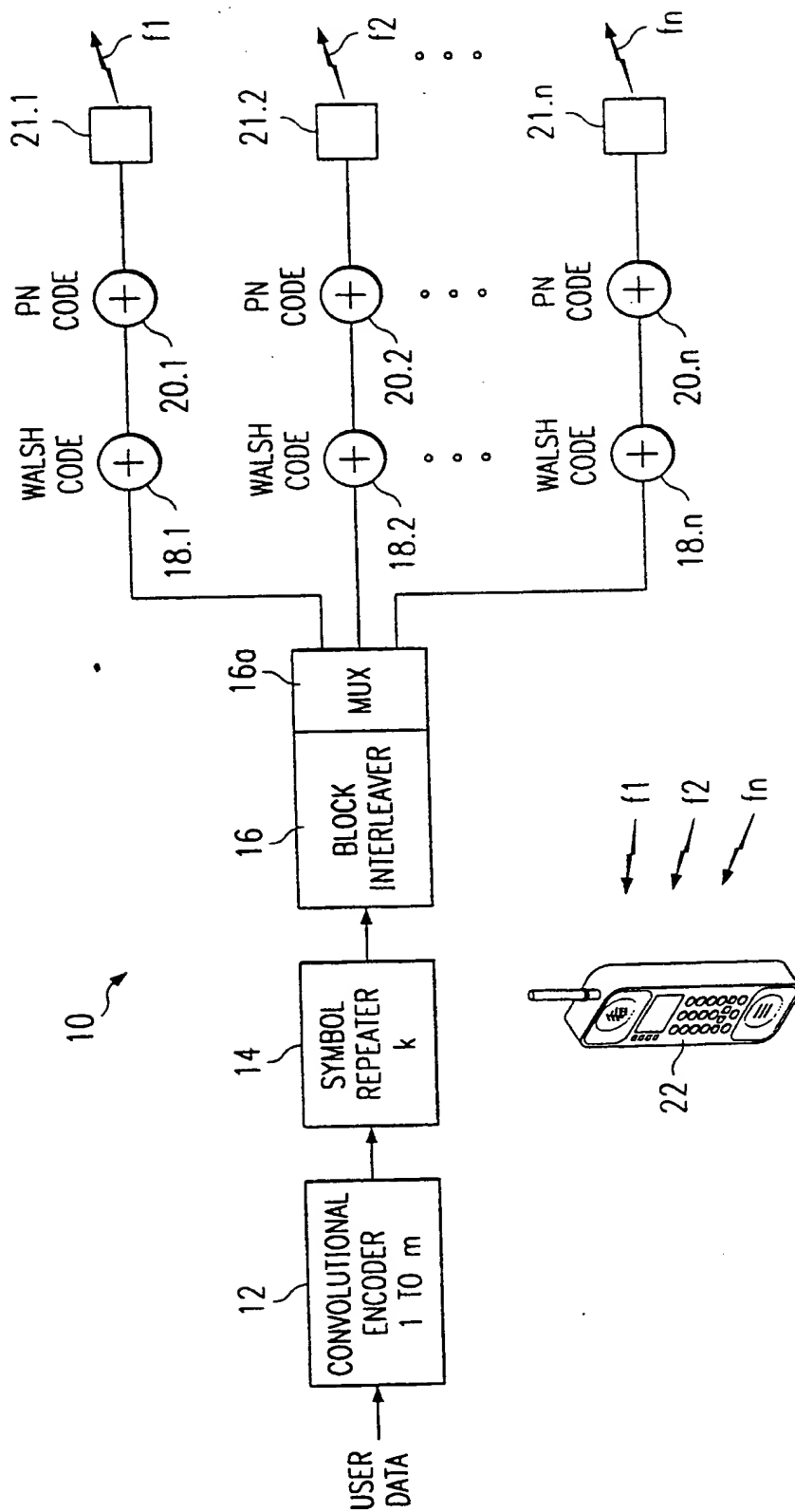
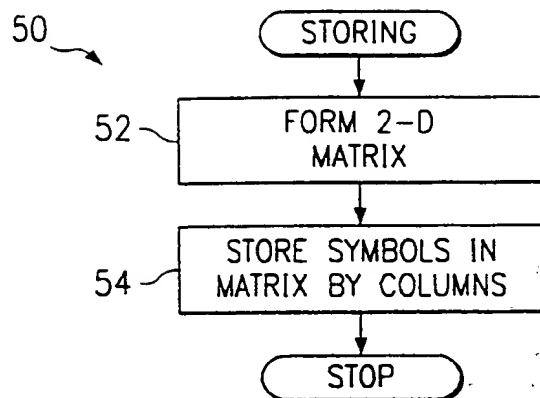
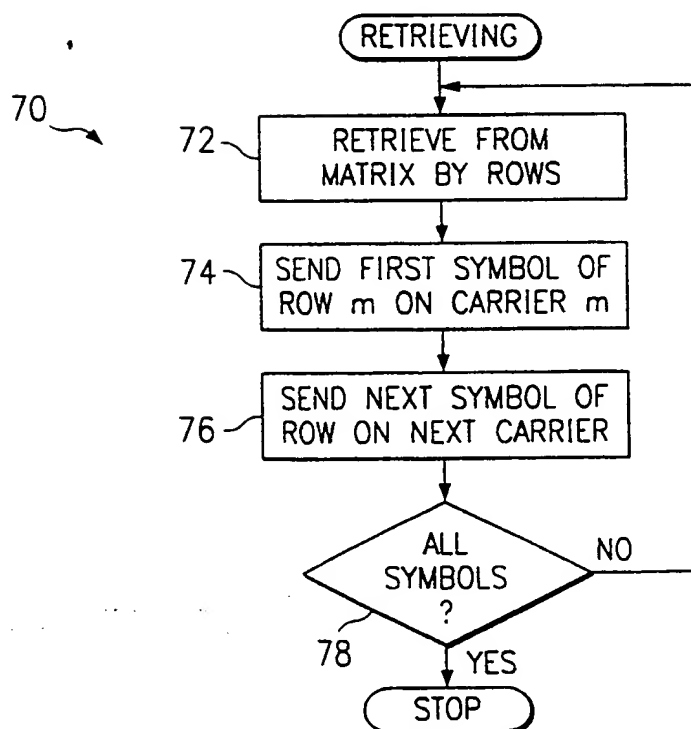


Fig. 1

2/2

Fig. 2*Fig. 3*

INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 98/00594

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04L27/26 H04L5/02 H04B1/69 H03M13/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04L H03M H04B H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 758 168 A (NIPPON TELEGRAPH & TELEPHONE) 12 February 1997 see column 1, line 5 - line 11 see column 6, line 6 - line 19 see column 17, line 56 - line 12; figure 3 see figures 9A, 9B	1-3, 7, 9
Y		4-6, 8, 11-20
X	WO 96 24196 A (PHILIPS ELECTRONICS NV ; PHILIPS NORDEN AB (SE)) 8 August 1996 see page 2, line 26 - page 3, line 15 see page 4, line 17 - page 5, line 27 see page 10, line 20 - page 12, line 22	1-3, 7, 9, 10
Y		4-6, 8, 11-20

	-/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

5 November 1998

Date of mailing of the international search report

18/11/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040. Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

Koukourlis, S

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/CA 98/00594

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No. .
X	CHEN Q ET AL: "PERFORMANCE OF A CODED MULTI-CARRIER DS-CDMA SYSTEM IN MULTI-PATH FADING CHANNELS" WIRELESS PERSONAL COMMUNICATIONS, vol. 2, no. 1/02, 1 January 1995, pages 167-183, XP000589618 see page 168, paragraph 1 see figure 1	1-10
Y	---	11-20
X	US 5 596 604 A (CIOFFI JOHN M ET AL) 21 January 1997 see abstract see column 1, line 12 - line 30 see column 2, line 8 - line 28 see column 3, line 16 - column 4, line 46 see column 7, line 53 - column 8, line 34	1-3,6-10
Y	---	4
A	---	5,11-20
X	SOUROUR E ET AL: "Performance of orthogonal multi-carrier CDMA in a multipath fading channel" 1994 IEEE GLOBECOM. COMMUNICATIONS: THE GLOBAL BRIDGE. CONFERENCE RECORD (CAT. NO.94CH34025), 1994 IEEE GLOBECOM. COMMUNICATIONS: THE GLOBAL BRIDGE, SAN FRANCISCO, CA, USA, 28 NOV.-2 DEC. 1994, pages 390-394 vol.1, XP002083299 ISBN 0-7803-1820-X, 1994, New York, NY, USA, IEEE, USA see page 390, paragraph II; figures 1,2	1-20

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/CA 98/00594

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0758168 A	12-02-1997	CA 2188455 A CN 1148919 A WO 9626582 A	29-08-1996 30-04-1997 29-08-1996
WO 9624196 A	08-08-1996	AU 4398696 A BR 9603962 A CN 1147883 A EP 0760182 A EP 0754320 A WO 9624098 A JP 9511377 T JP 9511606 T US 5737252 A US 5799033 A	21-08-1996 07-10-1997 16-04-1997 05-03-1997 22-01-1997 08-08-1996 11-11-1997 18-11-1997 07-04-1998 25-08-1998
US 5596604 A	21-01-1997	CA 2113330 A	18-02-1995

THIS PAGE BLANK (USPTO)

(51) International Patent Classification ⁶ : H04L 27/26, 5/02, H04B 1/69, H03M 13/22		A1	(11) International Publication Number: WO 98/59473
			(43) International Publication Date: 30 December 1998 (30.12.98)
(21) International Application Number: PCT/CA98/00594		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: 17 June 1998 (17.06.98)			
(30) Priority Data: 60/050,986 21 June 1997 (21.06.97) US 08/954,686 20 October 1997 (20.10.97) US			
(71) Applicant: NORTHERN TELECOM LIMITED [CA/CA]; World Trade Center of Montreal, 8th floor, 380 St. Antoine Street West, Montreal, Quebec H2Y 3Y4 (CA).		Published With international search report. With amended claims.	
(72) Inventor: JALALI, Ahmad; 7424 Wildflower Drive, Plano, TX 75024 (US).		Date of publication of the amended claims: 25 February 1999 (25.02.99)	
(74) Agents: O'NEILL, T., Gary et al.; Gowling, Strathy & Henderson, Suite 2600, 160 Elgin Street, Ottawa, Ontario K1P 1C3 (CA).			

A system and method that codes and interleaves data onto separate channels for transmission in a wireless multicarrier system, further comprising a code division multiple access (CDMA) transmitter for each of the carriers. The multicarrier wireless transmission system has an input terminal for receiving a plurality of user data bits. The system adds error-correcting bits to the user data bits. The system then arranges and stores the combination of error-correcting bits, collectively coded symbols, in a two dimensional matrix. The system arranges the coded symbols by writing them into the matrix according to columns, from left to right. The system then retrieves the symbols from the matrix according to rows, from top to bottom. The system then transmits the retrieved symbols on different carrier frequencies such that consecutive symbols are each transmitted on a different carrier frequency.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

AMENDED CLAIMS

[received by the International Bureau on 13 January 1999 (13.01.99);
original claim 9 cancelled; original claims 1, 3-6, 8, 10, 12 and 13 amended;
claims 10-20 renumbered as claims 9-19; remaining claims unchanged (4 pages)]

1. A telecommunication system comprising:
an input terminal for receiving a plurality of user data bits;
an error-correction device for generating a sequence of coded symbols
from the user data bits;
an interleaver for arranging and storing the coded symbols in a matrix;
and
an inverse-multiplexer for serially retrieving the coded symbols stored
in the matrix and distributing the retrieved coded symbols across a plurality
of carriers;
wherein the matrix is two-dimensional, the interleaver arranges the
coded symbols according to the first dimension and the inverse-multiplexer
retrieves the coded symbols according to the second dimension.
2. The system of claim 1 further comprising a device for repeating the
coded symbols.
3. The system of claim 1 wherein the error correction device comprises a
repeater and the sequence of coded symbols include duplicates of the user
data bits.
4. The system of claim 1 being a wireless multicarrier system further
comprising a code division multiple access ("CDMA") transmitter for each of
the plurality of carriers.

5. The system of claim 4 wherein a sub-sequence of multiple coded symbols is generated for each user data bit and wherein consecutive symbols of the sub-sequence are transmitted on different ones of the plurality of carriers.
6. The system of claim 2 wherein the repeated coded symbols are sequentially transmitted on different ones of the plurality of carriers.
7. The system of claim 1 wherein the error-correction device provides forward error correction.
8. The system of claim 1 wherein each of the plurality of carriers operates at a common bandwidth.
9. The system of claim 1 wherein the system may selectively use one or more of the plurality of carriers.
10. A method for arranging a frame of consecutive bits for transmission in a multicarrier system, the method comprising the steps of:
 - arranging and storing each bit of the frame in a two-dimensional matrix according to the first dimension of the matrix;
 - retrieving each bit stored in the matrix according to the second dimension to form an interleaved sequence of bits;
 - transmitting the interleaved sequence of bits with multiple carriers such that no two consecutive bits in the interleaved sequence of bits are transmitted on the same carrier.

11. The method of claim 10 wherein the step of transmitting utilizes multiple carriers and no two consecutive bits of the frame are transmitted on the same carrier.
12. The method of claim 10 wherein the first dimension represents a plurality of arrangements of the matrix, and where a first carrier transmits the first bit of a first arrangement and a second carrier transmits the first bit of a second arrangement.
13. The method of claim 10 wherein the step of transmitting utilizes a code division multiple access ("CDMA") transmitter for each carrier of the multicarrier system.
14. The method of claim 10 wherein the frame of bits includes error-correcting code.
15. The method of claim 14 wherein the frame of bits also includes user data and the error-correcting code is a duplicate of the user data.
16. The method of claim 10 wherein each carrier of the multicarrier system operates at a common bandwidth.
17. The method of claim 10 wherein the multicarrier system utilizes only a single carrier.

18. A system for arranging a frame of consecutive bits for transmission in a multicarrier wireless system, the system comprising:

means for arranging and storing each bit of the frame in a two-dimensional matrix according to the first dimension of the matrix;

means for retrieving each bit stored in the matrix according to the second dimension to form an interleaved sequence of bits;

a code division multiple access transmitter for transmitting the interleaved sequence of bits wherein the step of transmission utilizes multiple carriers operating at a common bandwidth and wherein no two consecutive bits of the frame are transmitted on the same carrier;

wherein the first dimension represents a plurality arrangements of the matrix, and where a first carrier transmits the first bit of the first arrangement and the second carrier transmits the first bit of the second arrangement.

19. The system of claim 18 wherein the frame of bits includes error-correcting code.